3 Prescriptive Packages

This chapter describes the *Prescriptive Packages* (also referred to as *Alternative Component Packages*). The prescriptive approach is one of two paths available for compliance. The other approach, the Computer Method, is a performance approach and is explained in Chapters 5. This compliance chapter is organized in the following subsections:

- Introduction
- Insulation
- Glazing / Fenestration
- Radiant Barriers
- Thermal Mass (Package C Only)
- Space Conditioning Systems
- Water-Heating Systems
- Compliance Documentation

Additions to existing buildings demonstrating compliance with the prescriptive package approach are discussed in Chapter 7.

3.1 Introduction

§151(f)

Buildings that comply with the prescriptive standards shall be designed, constructed and equipped to meet all of the requirements of one of the alternative packages of components shown in Tables No. 1-Z1 through 1-Z16 for the appropriate climate zone shown in Figure No. 1-A [see Chapter 1, Figure 1-1]. Installed components shall meet the following requirements:

You can comply with the *Standards* by installing a package of building conservation components and measures that make up an *Alternative Component Package*. Each package is a set of pre-defined performance levels for various building components. Each building component must meet or exceed the minimum conservation level specified in the package. There are two packages to choose from: Package C and Package D. The prescriptive packages are the simplest and least flexible compliance path. The only choice involved is the selection of which package to use within the designated climate zone.

Package D

Package D establishes the base prescriptive requirements. Maximum U-factors for fenestration products (windows + framing) is 0.75, 0.65 or 0.60 with colder climates requiring the lower U-factor. Shading requirements vary from no shading in coastal and mountain climates to a maximum 0.40 solar heat gain coefficient (SHGC) in climates with significant air conditioning loads. Only climate zone 16 requires slab edge insulation.

Package D is the reference house for performance compliance. Approved computer programs model a house with the features of Package D to determine the space-conditioning and water-heating budgets. Table 3-1 combines the Package D requirements for all 16 climate zones into one table. This can be used as a guide for

assessing how a proposed design compares to this package of features. More detail on each of the requirements follows later in this chapter.

Table 3-1 – Summary of Package D Requirements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BUILDING ENVELOPE																
Insulation minimums[2]																
Ceiling	R38	R30	R30	R30	R30	R30	R30	R30	R30	R30	R38	R38	R38	R38	R38	R38
Walls	R21	R13	R13	R13	R13	R13	R13	R13	R13	R13	R19	R19	R19	R21	R21	R21
"Heavy mass" walls	R4.76	R2.44	R2.44	R2.44	R2.44	R2.44	R2.44	R2.44	R2.44	R2.44	R4.76	R4.76	R4.76	R4.76	R4.76	R4.76
Below-grade walls	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R0	R13
Slab floor perimeter	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	R7
Raised floors	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]	R19[2]
Concrete raised floors	R8	R8	R0	R0	R0	R0	R0	R0	R0	R0	R8	R4	R8	R8	R4	R8
Radiant Barrier	NR	REQ	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
GLAZING																
Maximum U-factor[3]	0.65	0.65	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.65	0.65	0.65	0.65	0.65	0.65	0.60
Maximum total area	16%	16%	20%	20%	16%	20%	20%	20%	20%	20%	16%	16%	16%	16%	16%	16%
Solar Heat Gain Coefficient[4]																
South-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
West-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
East-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
North-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
THERMAL MASS[5]	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
SPACE-HEATING SYSTEM[6]																
Electric-resistant allowed	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
If gas, AFUE =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
If heat pump, split system HSPF[8] =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Single package system HSPF =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE-COOLING SYSTEM																
If split system A/C, SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Refrigerant charge and airflow testing or TXV	NR	REQ*	NR	NR	NR	NR	NR	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	NR
If single package A/C, SEER =	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
SPACE CONDITIONING DUCTS																
Duct Sealing	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*
DOMESTIC WATER-HEATING TYPE (System must meet budget, see §151 (b) 1 and (f) 8 and Tables 3-14 to 3-17)	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any	Any

* HERS rater field verification and diagnostic testing are required for this feature. As an alternative under Package D, better glazing and higher efficiency equipment can be used instead of the diagnostic testing of air distribution ducts, split system air conditioners and heat pumps. See Table 3-2 for the increased values, which vary by climate.

NR = Not Required REQ = Required MIN = Minimum

Alternative to Package D

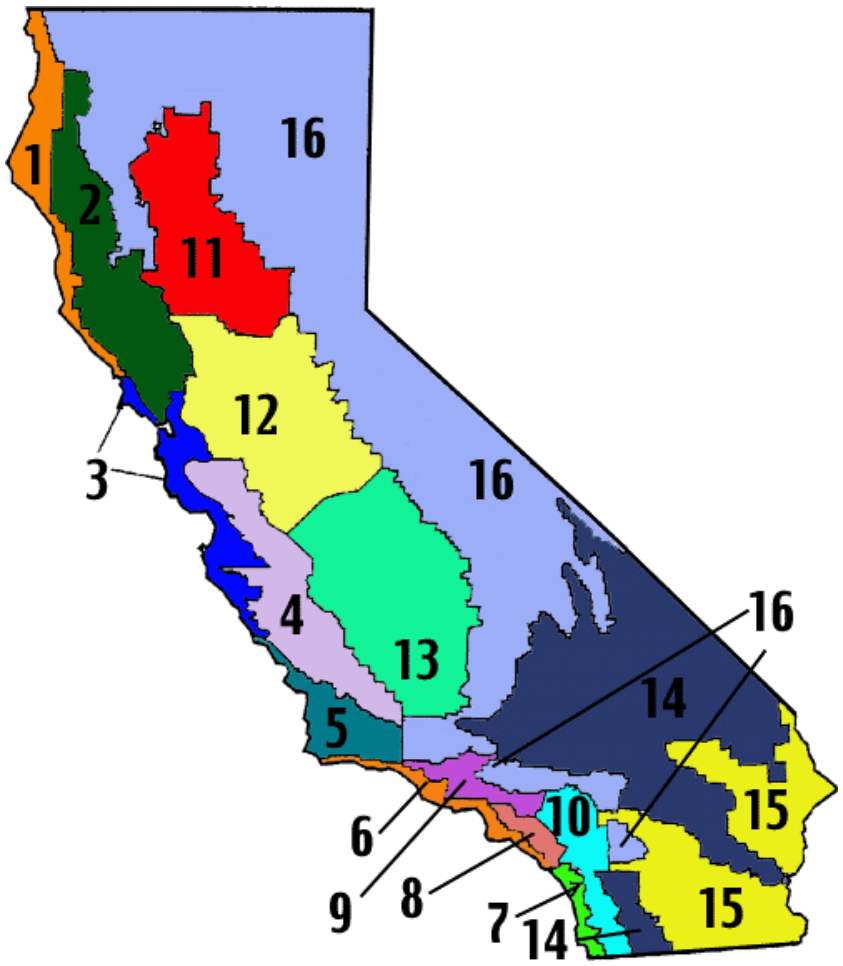
The base Package D requires that a HERS rater come to the building house (at least for a sample of the homes) and perform diagnostic testing to verify that the air distribution ducts are properly sealed and that split system air conditioners or heat pumps either have the proper refrigerant charge and the proper airflow across the evaporator coil or have a thermostatic expansion valve. If the builder does not want to do the field verification and diagnostic testing, then an alternative set of requirements are available that require more energy efficient fenestration and space conditioning equipment (see Table 3-2).

Table 3-2 – Summary of Alternative to Package D Requirements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Window U	0.55	0.40	0.55	0.40	0.55	0.55	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.55
WIndow SHGC	NR	0.35	NR	0.35	NR	NR	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.30	0.30	NR
SEER	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	11.0	11.0	11.0	11.0	12.0	12.0	13.0	MIN
AFUE or	90	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	90
HSPF	7.6	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	7.6

Note: These are alternative Package D prescriptive requirements. If these performance levels are provided, the requirements shown in Table 3-1 with an asterisk are not required. These include diagnostic testing of air distribution ducts, refrigerant charge and airflow and field verification of a thermostatic expansion valve.

Figure 3-1 – California Climate Zones



Package C

Package C may be used only if the building is in an area (1) where natural gas is not currently available and (2) where extension of natural gas service is impractical, as determined by the natural gas utility. Among the other Package C features are high performance fenestration products with maximum U-factors of either 0.50 or 0.40. Electric-resistance water heating may be used in conjunction with a solar water-heating system or a wood stove boiler. Slab edge insulation is required in all climate zones. Table 3-3 lists all of the requirements for Package C in all 16 climate zones. More detail on each of the requirements follows.

Table 3-3 – Summary of Package C Requirements

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
BUILDING ENVELOPE																
Insulation minimums[2]																
Ceiling	R49	R49	R38	R38	R38	R38	R38	R38	R38	R49	R49	R49	R49	R49	R49	R49
Walls	R29	R29	R25	R25	R25	R21	R21	R21	R21	R25	R29	R29	R29	R29	R29	R29
Slab floor perimeter	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7	R7
Floors	R30	R30	R30	R30	R30	R21	R21	R21	R21	R30	R30	R30	R30	R30	R21	R30
Radiant Barrier	NR	REQ	NR	REQ	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
GLAZING																
Maximum U-factor[3]	0.40	0.40	0.40	0.40	0.40	0.50	0.50	0.50	0.50	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Maximum total area	14%	16%	14%	14%	16%	14%	14%	14%	14%	16%	16%	16%	16%	14%	16%	14%
SOLAR HEAT GAIN COEFFICIENT[4]																
South-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
West-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
East-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
North-facing glazing	NR	0.40	NR	0.40	NR	NR	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	NR
THERMAL MASS[5]	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ
SPACE-HEATING SYSTEM[6]																
Electric-resistant allowed	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]	Yes[7]
If gas, AFUE =	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%	78%
If heat pump, split system HSPF[8] =	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Single package system HSPF =	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
SPACE-COOLING SYSTEM																
If split system A/C, SEER =	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Refrigerant charge and airflow testing or TXV	NR	REQ*	NR	NR	NR	NR	NR	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	NR
If single package A/C, SEER =	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7	9.7
SPACE CONDITIONING DUCTS																
Duct sealing	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*	REQ*
DOMESTIC WATER-HEATING TYPE	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]	Any[9]
System must meet budget, see §151 (b) 1 and (f) 8																

* HERS rater field verification and diagnostic testing are required for this feature. There is no alternative to Package C field verification and diagnostic testing.

Table 3-4 – Notes To The Low-Rise Residential Packages

See also Table 3-1, Table 3-2 and Table 3-3 (Also Tables 1-Z1 Through 1-Z16 of §151)

[1] Package C is the only package that allows electric-resistance space heating. Package C may be used only if the building is in an area (1) where natural gas is not currently available and (2) where extension of natural gas service is impractical, as determined by the natural gas utility. Package D allows more glazing area in some zones with moderately high insulation levels; slab edge insulation is required in Climate Zone 16.

[2] The R-values shown for ceiling, wood frame wall and raised floor are for wood-frame construction with insulation installed between the framing members. For alternative construction assemblies, see § 151 (f) 1 A.

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. Any insulation installed on heavy mass walls must be integral with, or installed on the outside of, the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be exposed to the room air.

[3] For glazing U-factor rating procedures and labeling requirements see §116 (a) 2.

[4] Values specified are maximum allowable values. If the package specifies a solar heat gain coefficient the builder shall meet the requirements of §151 (f) 4.

[5] If the package requires thermal mass, meet the requirements of §151 (f) 5.

[6] Automatic setback thermostats must be installed in conjunction with all space-heating systems in accordance with §151 (f) 9.

[7] Ducts in Package C shall be insulated to an installed value of at least R-8.

[8] HSPF means, "heating seasonal performance factor."

[9] Electric-resistance water heating is allowed as the main water heating source in Package C only if the water heater is located within the building envelope and a minimum of 25 percent of the energy for water heating is provided by a passive or active solar system or a wood stove boiler. The wood stove boiler credit is not allowed in Climate Zones 8, 10, and 15, nor in localities that do not allow wood stoves.

When a HERS Rater is Not Needed

Packages C and D require that air distribution ducts in all climate zones be diagnostically tested by a HERS rater. A HERS rater must also diagnostically test split system air conditioners or heat pumps in climates 2 and 8 through 15 to verify correct refrigerant charge and airflow; alternatively, the HERS rater must verify that the equipment has a thermostatic expansion valve (TXV).

The requirements for field verification and/or diagnostic testing only apply when equipment or systems are installed that require verification or testing. If a house has no air distribution ducts, then a HERS rater does not have to test the ducts, since there are not ducts to test. Similarly, if a house does not have a split system air conditioner or heat pump, then a HERS rater does not have to diagnostically test the refrigerant charge and airflow or verify that there is a TXV, because the requirements do not apply. Likewise, if compliance for a house is achieved using an alternative that does not require a TXV, then a HERS rater does not have to come to the site and verify that one has been installed.

A HERS rater is not required when measures that require field verification or diagnostic testing are not installed in the building. A common situation is when the Alternative to Package D is used (see Table 3-2). Another example is a house with no air conditioning and a heating system that does not have ducts, e.g. hydronic baseboards or radiant panels.

Refer to Section 4.4.2 for details on conditions under which a HERS rater's certification or diagnostic testing is required.

3.2 Insulation

This section presents all the insulation requirements for ceilings, walls, below-grade walls, slab perimeter insulation and raised floors.

§151(f)1

1. *Insulation*

   A. *Ceiling, wall, slab floor perimeter, and raised floor insulation shall be installed which has an R-value equal to or higher than that shown in Tables No. 1-Z1 through 1-Z16. The minimum opaque ceiling, wall (including heated basements*

and crawl spaces), and raised floor R-values shown are for insulation installed between wood framing members.

ALTERNATIVE to Section 151(f)1A: The insulation requirements of Tables No. 1-Z1 through 1-Z16 may also be met by ceiling, wall, or floor assemblies that meet equivalent minimum R-values that consider the effects of all elements of the assembly, using a calculation method approved by the Executive Director.

EXCEPTION to Section 151(f)1A: Raised floor insulation may be omitted if the foundation walls are insulated to meet the wall insulation minimums shown in Tables No. 1-Z1 through 1-Z16, a vapor barrier is placed over the entire floor of the crawl space, and the vents are fitted with automatically operated louvers.

B. *The minimum depth of concrete-slab floor perimeter insulation shall be 16 inches or the depth of the footing of the building, whichever is less.*

EXCEPTION to Section 151(f)1B: Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space, covered porches, or covered patios.

The minimum insulation requirements (R-values) for the packages assume that the insulation is installed in the cavity or between wood framing members. When continuous insulation is used, it is better to show compliance by comparing the U-factor of the proposed construction to an equivalent wood framed construction. For example, an R-19 wall may be achieved with either R-19 batt insulation set within 2 x 6 framing, or with R-11 batt insulation placed between 2 x 4 framing plus a minimum of R-4.61 rigid insulation applied to the outside of the framing.

Note: R-value is a minimum; U-factor (the inverse of R-value) is a maximum. A higher R-value is more energy efficient; a lower U-factor is more energy efficient. See the *Glossary* for definitions of *R-Value* and *U-factor*.

For wall, roof, floor and slab insulation, the builder should verify the following:

- All insulation levels meet or exceed the levels indicated on the CF-1R form, which must be on the plans. Insulation levels must also be indicated on the plans independently of the CF-1R.
- The frame type of the envelope must match that specified on the CF-1R form.
- The insulation contractor's must complete the Insulation Certificate (IC-1) and either post it at the job site or make it available to the inspector at appropriate inspections.

The field inspector should check the Certificate of Compliance (CF-1R) form for the required insulation levels and frame type. Check the Insulation Certificate (IC-1) for consistency with the CF-1R. Check that insulation is installed in all wall cavities including narrow cavities between framing members at windows and doors. Check for complete and uniform installation of insulation in all parts of ceilings.

3.2.1 Ceiling Insulation

Specifying the minimum R-value indicated in the selected package can show prescriptive compliance of a wood-frame ceiling. For metal framing or as an alternative to meeting the installed R-value, document the U-factor as specified in Section 2.8. The U-factor of the proposed ceiling assembly must be *less than or equal to* the U-factor of a wood-frame ceiling assembly with the minimum R-value installed. The table below shows the U-factor for typical ceiling insulation systems.

Table 3-5 – Ceiling Assembly U-factors, Wood Frame

Insulation	*Framing/Spacing*	*U-factor*
R-30	2 x 12 / 16" o.c.	0.035
R-30	2 x 10 / 16" o.c.	0.036
R-30	2 x 4 / 24" o.c.	0.031
R-38	2 x 14 / 16" o.c.	0.028
R-38	2 x 12 / 16" o.c.	0.030
R-38	2 x 4 / 24" o.c.	0.025
R-49	2 x 4 / 16" o.c.	0.019
R-49	2 x 4 / 24" o.c.	0.019

3.2.2 Framed Wall Insulation

Wood framed walls may be shown to comply by specifying the minimum R-value indicated in the selected package. For metal or steel framed walls, or as an alternative to meeting the installed R-value, the designer may document the U-factor. The U-factor of the proposed wall assembly must be *less than or equal to* the U-factor of a wood-frame wall assembly with the minimum R-value installed.

Table 3-6 – Wall Assembly U-factors, Wood Frame

Insulation	*Framing/Spacing*	*U-factor*
R-13	2 x 4 / 16" o.c.	0.088
R-13	2 x 4 / 24" o.c.	0.084
R-19	2 x 6 / 16" o.c.	0.065
R-19	2 x 6 / 24" o.c.	0.063
R-21	2 x 6 / 16" o.c.	0.059
R-21	2 x 6 / 24" o.c.	0.056

Straw bales that are 23 inches by 16 inches and that have stucco or plaster on the inside and outside vertical surfaces are assumed to have a thermal resistance of R-30. Performance data on other sizes of bales was not available at the time of publication of this *Manual*.

Metal framed assemblies will require rigid insulation in order to meet the maximum U-factor criterion.

Table 3-7 – Steel Frame Wall U-factors

Wall	*Rigid Insulation*	*Framing/ Spacing*	*U-factor*
R-13	0	2 x 4 / 16	0.195
R-13	7	2 x 4 / 16	0.081
R-13	5.28	2 x 4 / 24	0.087
R-15	7	2 x 4 / 24	0.074
R-19	8.8	2 x 6 / 16	0.064
R-19	8.8	2 x 6 / 24	0.060

3.2.3 Mass Wall Insulation

§151(f), footnote 2 to Tables No. 1-Z1 through 1-Z16)

The heavy mass wall R-value in parentheses is the minimum R-value for the entire wall assembly if the wall weight exceeds 40 pounds per square foot. The light mass wall R-value in brackets is the minimum R-value for the entire assembly if the heat capacity of the wall meets or exceeds the result of multiplying the bracketed minimum R-value by 0.65. Any insulation installed on heavy or light mass walls must be integral with or installed on the outside of the exterior mass. The inside surface of the thermal mass, including plaster or gypsum board in direct contact with the masonry wall, shall be

exposed to the room air. The exterior wall used to meet the specified R-value cannot also be used to meet the thermal mass requirement.

(§101(b))

"HEAT CAPACITY (HC) of an assembly is the amount of heat necessary to raise the temperature of all the components of a unit area in the assembly one degree F. It is calculated as the sum of the average thickness times the density times the specific heat for each component, and is expressed in Btu per square foot per degree F."

Mass walls that have no framing are not required to meet the minimum mandatory wall insulation requirements of §150(c). The R-value listed in Tables No. 1-Z1 through 1-Z16 (in the standard) is the minimum R-value for the entire wall assembly, including insulation and both interior and exterior air films. Where the Package indicates "NA" for a mass wall, the assembly must comply with insulation requirements described for "framed wall insulation." Package D has a special requirement for heavy mass walls (weight greater than 40 lb/ft² of wall surface area). Such walls require R-2.44 in climates 2 through 10 and R-4.76 in the other climates. All other walls (including light mass walls) must have a U-factor equal to or less than a wood wall with the prescribed insulation levels. Table 3-8 has data to help determine wall weight per cubic foot for various materials. The wall thickness needed to meet the requirements of Package D will depend on the weight of the materials used.

Table 3-8 – Thermal Mass Properties

Material	***Density (lb/ft^3)***	***Specific Heat (Btu/lb-°F)***
Adobe	120	0.20
Heavy Concrete	140	0.20
Lightweight Concrete	85	0.20
Gypsum	50	0.26
Masonry Veneer	127	0.20
Masonry Infill	120	0.20
Concrete Masonry Unit	105	0.20
Grouted Concrete		
Masonry Unit	134	0.20
Stucco	105	0.20
Tile in Mortar	120	0.20
Solid Wood (fir)	32	0.33

3.2.4 Raised Floor Insulation

Exterior raised-floor insulation shall be installed between floor joists with a means of support that prevents the insulation from falling, sagging or deteriorating. Two approaches that accomplish this are:

- Nailing insulation hangers 18 inches apart prior to rolling out the insulation. Hangers are heavy wires up to 48 inches long with pointed ends, which provide positive wood penetration.
- Attaching wire mesh to form a basket between joists to support the insulation. The mesh is nailed or stapled to the underside of the joists.

Controlled Ventilation Crawlspace

The *Standards* exempt the installation of raised-floor insulation if three conditions are met: (1) the foundation walls are insulated to meet the wall insulation minimums of the package, (2) a vapor barrier is placed over the entire floor of the crawl space and (3) the vents are fitted with automatically operated louvers. (See also *Controlled Ventilation Crawl Space* in Appendix G, the *Glossary*.)

Prescriptive compliance of a wood-frame raised floor can be shown by specifying the minimum R-value indicated in the selected package. For metal framing, or as an alternative to meeting the installed R-value, the compliance author must document the U-factor as specified in Section 2.8. The U-factor of the proposed floor assembly must be *less than or equal to* the U-factor of a wood-frame floor assembly with the minimum R-value installed.

Table 3-9 – Floor Assembly U-factors, Wood Frame

Insulation	*Framing/ Spacing*	*Crawl Space*	*U-factor*
R-13	2 x 6 / 16” o.c.	NO	0.064
R-13	2 x 6 / 16” o.c.	YES	0.046
R-19	2 x 8 / 16“ o.c.	NO	0.048
R-19	2 x 8 / 16” o.c.	YES	0.037
R-21	2 x 8 / 16” o.c.	NO	0.045
R-21	2 x 8 / 16” o.c.	YES	0.035
R-30	2 x 10 / 16” o.c.	NO	0.034
R-30	2 x 10 / 16” o.c.	YES	0.028

3.2.5 Concrete Raised Floor Insulation and Below-Grade Walls

When the selected Alternative Component Package requires raised-floor insulation, the requirement may be met by installing insulation with the required R-value or by meeting an equivalent U-factor for all components of the floor assembly. Where the package indicates “N/A” for concrete raised floor insulation, no insulation is required.

When a conditioned space will have concrete walls that are below grade, Alternative Component Package D in climate zone 16 requires R-13 insulation.

3.2.6 Slab Floor Perimeter Insulation

When slab-edge insulation is required, the insulation must be installed to a maximum depth of 16 inches or to the bottom of the footing, whichever is less. The depth is measured from the top of the insulation, as near the floor line as practical, to the bottom edge of the insulation.

Perimeter insulation is not required along the slab edge between conditioned space and the concrete slab of an attached unconditioned enclosed space, covered porches or covered patios. Neither would it be practical or necessary to insulate concrete steps attached to the outside slab edge.

In situations where the slab is below grade and slab-edge insulation is being applied to a basement or retaining wall, the top of the slab-edge insulation should be placed as near to ground level as possible and extended down 16 inches. In situations where slab is above grade and slab edge is being applied, the top of the slab-edge insulation should be placed at the top of the slab.

Slab-edge insulation should be protected from physical damage and ultraviolet light exposure. Protection of the slab-edge insulation is important because deterioration from moisture, pest infestation, ultraviolet light exposure and other physical degradation can significantly reduce the effectiveness of the insulation.

3.3 Glazing / Fenestration

3.3.1 Glazing / Fenestration U-factor

§101(b)

FENESTRATION PRODUCT is any transparent or translucent material plus any sash, frame, mullions and dividers, in the envelope of a building, including, but not limited to, windows, sliding glass doors, French doors, skylights, curtain walls, garden windows, and other doors with a glazed area of more than one half of the door area.

FENESTRATION SYSTEM means a collection of fenestration products included in the design of a building. (See "fenestration product")

FIELD-FABRICATED FENESTRATION PRODUCT OR EXTERIOR DOOR is a fenestration product or exterior door whose frame is made at the construction site of standard dimensional lumber or other materials that were not previously cut, or otherwise formed with the specific intention of being used to fabricate a fenestration product or exterior door. Field fabricated does not include site-assembled frame components that were manufactured elsewhere with the intention of being assembled on site (such as knocked-down products, sunspace kits, and curtain walls).

MANUFACTURED FENESTRATION PRODUCT is a fenestration product typically assembled before delivery to a job site. A "knocked-down" or partially assembled product sold as a fenestration product must be considered a manufactured fenestration product and meet the rating and labeling requirements for manufactured fenestration products.

SITE-BUILT FENESTRATION PRODUCTS are fenestration products designed to be field-glazed or field assembled units comprised of specified framing and glazing components. Site-built fenestration is eligible for certification under NFRC 100-SB, and may include both vertical glazing and horizontal glazing.

§151 (f) 3. A.

3. Glazing

A. Installed fenestration products shall have U-factors equal to or lower than those shown in Tables No. 1-Z1 through 1-Z16. The U-factor of installed fenestration products shall be determined pursuant to Section 151 (e) 5.

§ 151 (e) 5

5. The U-factor of installed manufactured fenestration products shall be those certified by an approved independent certification organization in accordance with Section 116. The U-factor of field-fabricated fenestration products shall be those values from Section 116, Table No. 1-D, based on an approved method that determines the area weighted average U-factor for generic types of products.

Each Alternative Component Package establishes a maximum U-factor for all the fenestration products in the building. This includes skylights, doors with more than one-half the door area as glass, and windows. Each window, glass door or skylight must have a U-factor less than or equal to that specified in the selected package. If any of the fenestration products has a higher U-factor, the building does not comply with the prescriptive approach.

The U-factor criterion applies to both windows and skylights. Refer to Section 8.4 for more information on fenestration products. Section 8.4 also addresses bay windows.

The U-factor of each fenestration product being installed must be *equal or lower than* that specified on the plans and CF-1R. An Installation Certificate (CF-6R) is completed for the fenestration products installed.

Check the Certificate of Compliance (CF-1R) form for the required fenestration U-factor. Compare this against the CF-6R for the U-factor of installed products.

3.3.2 Maximum Glazing / Fenestration Area

§151(f) 3 B.

B. Total glazing area shall not exceed the percentage of conditioned floor area specified in Tables No. 1-Z1 through 1-Z16.

The prescriptive packages limit the total area of fenestration products in the building. Package D limits glazing area to 20% of the floor area in climates 3, 4 and 6 through 10; 16% is permitted in the other climate zones. Package C permits either 14% or 16%, depending on climate zone. With the prescriptive packages, there is no restriction with regard to the orientation of the glass. Skylight area is included in the maximum glazing percentage. Maximum glazing is expressed as a percent (%), representing the total area of fenestration products (in square feet) divided by the total conditioned floor area, then multiplying by 100 (see *Fenestration Area* in the *Glossary*).

$$\frac{\text{Fenestration (ft}^2\text{)}}{\text{Floor Area (ft}^2\text{)}} \times 100 = \%\ \text{fenestration}$$

The area of glass shown on the CF-1R is the maximum amount that can be installed without demonstrating that the total area of glass in the building is within the percentage allowed by the package used for compliance.

Complete the fenestration portion of the CF-6R. Compare the installed glass area both visually and as indicated on the CF-1R with the allowed glass areas indicated on the CF-1R. If more glass is installed, it must be demonstrated that the building does not exceed the glass area allowed by the prescriptive approach. Without such proof, the building is not in compliance with the *Standards*.

3.3.3 Shading

Where Tables No. 1-Z1 through 1-Z16 require a solar heat gain coefficient of 0.40 or lower, the requirements shall be met by either:

§151 (f) 4

A. A fenestration product listed by the manufacturer to have the required solar heat gain coefficient; or

B. An exterior operable louver or other exterior shading device that meets the required solar heat gain coefficient; or

C. A combination of exterior shading device and fenestration product to achieve the same performance as achieved in A.

D. For south-facing glazing by optimal overhangs installed so that the south-facing glazing is fully shaded at solar noon on August 21 and substantially exposed to direct sunlight at solar noon on December 21.

Except where the UBC requires emergency egress, exterior shading devices must be permanently attached to the outside of the structure with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps or ties).

Solar heat gain coefficient (SHGC) is a measure of the effectiveness of fenestration in rejecting solar heat gain (see *Shading* in the *Glossary*). The SHGC is a fractional value that ranges between 0 and 1. A *higher value indicates less shading effectiveness* with a greater amount of solar radiation penetrating the combined glazing/ frame/shade assembly and absorbed as heat. *A lower SHGC value corresponds to better shading effectiveness* with less solar gain making its way into the building.

Fenestration products are required to have a SHGC of 0.40 or less in the California climates with a significant cooling load (all except 1, 3, 5, 6, and 16). SHGCs listed for the prescriptive packages represent maximum values not to be exceeded for movable shading devices or intrinsic shading properties of the fenestration product. When the prescriptive packages show "NR", no specific shading needs to be installed. The requirements for an SHGC of 0.40 or less may be met by a window, skylight or other fenestration unit that the manufacturer certifies to have the required SHGC, or by installing an exterior shading device, or by some combination of the two.

Note: Interior shading devices other than the default may *not* be used to achieve compliance with the required SHGC.

To determine compliance with prescriptive requirements for a maximum SHGC, options include constructing an optimal overhang (see below) or using a value from:

- Chapter 2 of this *Manual* Table 2-3 – Default Solar Heat Gain Coefficients (From Table 1-E of §116 of the Standards) for default SHGC values for fenestration products.
- Product literature for the proposed fenestration product(s) showing a value equal or lower than required by the Alternative Component Package selected.
- Table 3-10 – Allowed Solar Heat Gain Coefficients Used for Form S for SHGC values of exterior shading devices.
- Form S calculations showing the combined $SHGC_{shade\ open}$ is less than the target value for the proposed fenestration and one of the exterior devices listed in Table 3-1. This target value is determined from a Form S calculation for an $SHGC_{fenestration}$ of 0.40 with default bugscreen exterior shading. Refer to *Shading* in the *Glossary* for an explanation of how to calculate a Form S SHGC for different combinations of exterior devices and glass types.

Note: *To gain credit for exterior shades, they must be permanently attached to the outside of the residence with fasteners that require additional tools to remove (as opposed to clips, hooks, latches, snaps or ties). Exterior shades on windows or skylights that are prohibited by the UBC from being permanently attached for emergency egress reasons are exempt from this requirement.*

Table 3-10 – Allowed Solar Heat Gain Coefficients Used for Form S

Exterior Shading Device	***SHGC***
Bug Screen (default)	0.76
Woven SunScreen	0.30
Louvered SunScreen	0.27
Low Sun Angle Sunscreen	0.13
Roll-down Awning	0.13
Roll -down Blinds or Slats	0.13
None (skylights only/skylight default)	1.00

Shading requirements for south glazing can also be met by installing any overhang that completely shades the glazing at solar noon on August 21st and substantially exposes the glazing to direct sunlight at solar noon on December 21st. Any well-designed overhang,

designed to meet this performance specification, may be used when shading is required for south glazing.

When shading is required, it is specified on the CF-1R form that must be on the plans and must be constructed or installed as specified for the building to be in compliance with the prescriptive approach. The only alternative to installing an exterior shading device or constructing an overhang used to achieve compliance is to install a fenestration product with an equal or lower SHGC value as specified on the CF-1R.

With the prescriptive approach, there are two options for compliance:

- Shading devices or overhangs specified on the CF-1R must be installed.
- Install a fenestration product with an equal or lower SHGC value as shown on the CF-1R.

3.4 Radiant Barriers

(§101(b), 151(f)2)

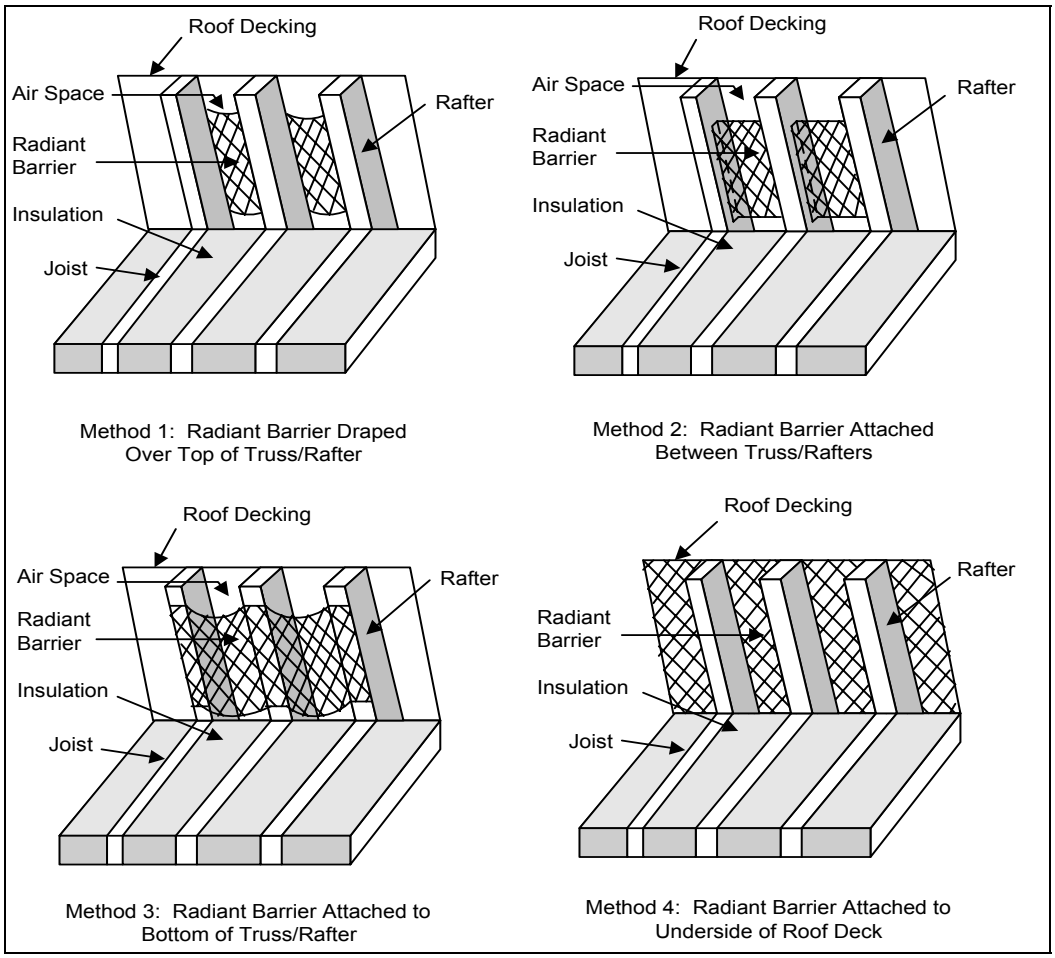
RADIANT BARRIER is any reflective material that has an emittance of 0.05 or less, tested in accordance with ASTM C-1371-98 or ASTM E408-71(1996)e1, and is certified to the California Department of Consumer Affairs as required by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

§151(f)2

Radiant Barrier. A radiant barrier required in Tables 1-Z1 through 1-Z16 is any reflective material that has an emittance of 0.05 or less, tested according to ASTM C-1371-98 or ASTM E408-71(1996)e1, and that is certified to the Department of Consumer Affairs as required by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.

A radiant barrier is required for roofs in climate zones with significant cooling loads (2, 4, and 8 through 15). The radiant barrier is a reflective material that reduces radiant heat transfer caused by solar heat gain to the roof. This reduces the radiant gain to ducts and insulation located below the radiant barrier.

Figure 3-2 – Methods of Installation for Radiant Barriers



Requirements from ACM

The Residential ACM Manual describes the radiant barrier installation requirements as follows:

Radiant barriers must meet specific eligibility and installation criteria to be modeled by any ACM and receive energy credit for compliance with the energy efficiency standards for low-rise residential buildings.

- *The emittance of the radiant barrier must be less than or equal to 0.05 as tested in accordance with ASTM C-1371-98 or ASTM E408-71(1996)e1.*
- *Installation must be in conformance with ASTM C-1158-97 (Standard Practice For Use and Installation Of Radiant Barrier Systems (RBS) In Building Construction.), ASTM C-727-90(1996)e1 (Standard Practice For Installation and Use Of Reflective Insulation In Building Constructions.), ASTM C1313-975 (Standard Specification for Sheet Radiant Barriers for Building Construction Applications), and ASTM C-1224-99 (Standard Specification for Reflective Insulation for Building Applications) and the radiant barrier must be securely installed in a permanent manner with the shiny side facing down toward the attic floor. Moreover, radiant barriers must be installed to the roof truss/rafters (top chords) in any of the following methods, with the material:*

  1. *Draped over the truss/rafter (the top chords) before the upper roof decking is installed.*
  2. *Spanning between the truss/rafters (top chords) and secured (stapled) to each side.*

3. *Secured (stapled) to the bottom surface of the truss/rafter (top chord). A minimum air space must be maintained between the top surface of the radiant barrier and roof decking of not less than 1.5 inches at the center of the truss/rafter span.*

4. *Attached [laminated] directly to the underside of the roof decking. The radiant barrier must be laminated and perforated by the manufacturer to allow moisture/vapor transfer through the roof deck.*

In addition, the radiant barrier must be installed to cover all gable end walls and other vertical surfaces in the attic.

- *The attic must be ventilated to:*

  1. *conform to manufacturer's instructions.*

  2. *provide a minimum free ventilation area of not less than one square foot of vent area for each 150 square feet of attic floor area.*

  3. *provide no less than 30 percent upper vents.*

     (Ridge vents or gable end vents are recommended to achieve the best performance. The material should be cut to allow for full air flow to the venting.)

- *The radiant barrier (except for radiant barriers laminated directly to the roof deck) must be installed to:*

  1. *have a minimum gap of 3.5 inches between the bottom of the radiant barrier and the top of the ceiling insulation to allow ventilation air to flow between the roof decking and the top surface of the radiant barrier.*

  2. *have a minimum of six (6) inches (measured horizontally) left at the roof peak to allow hot air to escape from the air space between the roof decking and the top surface of the radiant barrier.*

- *When installed in enclosed rafter spaces where ceilings are applied directly to the underside of roof rafters, a minimum air space of 1 inch must be provided between the radiant barrier and the top of the ceiling insulation, and ventilation must be provided for every rafter space. Vents must be provided at both the upper and lower ends of the enclosed rafter space.*

- *The product must meet all requirements for California certified insulation materials [radiant barriers] of the Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, as specified by CCR, Title 24, Part 12, Chapter 12-13, Standards for Insulating Material.*

The use of a radiant barrier and the criteria specified above for covering all gable end walls and other vertical surfaces in the attic, and for providing attic ventilation shall be listed in the Special Features and Modeling Assumptions listings of the CF-1R and C-2R and described in detail in the ACM Compliance Supplement.

For the heating season, Equation 4.1 is the expression for the U-value modifier; for the cooling season, Equation 4.2. To determine the U-value for a ceiling with a radiant barrier, multiply the U-value of the ceiling assembly without the radiant barrier times the U-value modifier. The U-value modifiers are calculated from equations 4.1 and 4.2.

For installed insulation greater than R-8:

$$\text{UvalMod}_{\text{Heating}} = (-11.404 \times U^2) + (0.21737 \times U) + 0.92661 \qquad \text{Equation 4.1}$$

$$\text{UvalMod}_{\text{Cooling}} = (-58.511 \times U^2) + (3.22249 \times U) + 0.64768 \qquad \text{Equation 4.2}$$

Otherwise, these modifiers are 1.000.

Radiant Barriers in Closed rafter Spaces

Installation of radiant barriers is somewhat more challenging in the case of closed rafter spaces. A minimum vent area of one square foot is required for each 150 square feet of attic floor area. This ratio may be reduced to 1 to 300 if a ceiling vapor retarder is present or if high (for example, ridge or gable vents) and low (soffit vents) attic ventilation is used. Since part of the vent area is blocked by meshes or louvers, the net free area of a vent must be considered for meeting ventilation requirements. It is difficult to achieve uninterrupted air movement in closed rafter spaces and to meet the minimum ventilation requirements making such spaces more prone to moisture damage compared to open attic spaces. Also radiant barriers must 'see' air spaces this places more restrictions on installing them in closed rafter spaces. In closed rafter spaces, the depth of the rafters severely limits the provision of this gap. Rafters used in home construction are usually not large enough to provide the proper amount of insulation to fit in the cavity between the rafters and still have a ventilation space. Both are required to have an energy efficient building envelope. The depth of the rafters dictates a certain volume of space that can be filled with only so much insulation and still have an air space at the top for natural ventilation. 10 inches thick batt insulation in 2x12 rafters leaves less than 2 inches for air movement and installing radiant barriers.

There are two primary choices of radiant barrier placement in the cathedral ceiling design. The radiant barrier can be draped over the rafter or attached to the bottom of the decking. Ensure adequate ventilation by providing continuous venting through the sides and protecting this opening by overhangs.

Check the Certificate of Compliance (CF-1R) to see if a radiant barrier is required and review form IC-1 (Insulation Certificate) for consistency. Check that the radiant barrier is installed with the shiny side facing the attic air space.

3.5 Thermal Mass (Package C Only)

§151(f)4

Thermal mass required for Package C in Tables No. 1-Z1 through 1-Z16 shall meet or exceed the minimum interior mass capacity specified in Table No. 1-U [Table 3-11].:

Table 3-11 – Interior Mass Capacity Requirements for Package C

Floor Type	Minimum Interior Mass Capacity
C (slab floor)	2.36 X Ground Floor Area (ft²)
C (raised floor)	0.18 X Ground Floor Area (ft²)

The mass requirements in the above table may be met by calculating the combined interior mass capacity of the mass materials using Equation 3-1.

Calculation of Interior Mass Capacity

Equation 3-1

$$IMC = [(A_1 \times UIMC_1) + (A_2 \times UIMC_2) + (A_n \times UIMC_n)]$$

Where,

A_n = Area of mass material n, and

$UIMC_n$ = Unit Interior Mass Capacity of mass material n

Note: Table 3-12 and Table 3-13 of the Commission's *Residential Manual* list the Unit Interior Mass Capacity (UIMC) of various mass materials.

Thermal mass stores heat as a house warms and slowly releases the stored heat as the house cools. This helps moderate temperature variations within the space and reduces the need to use heating and cooling equipment. Typical materials that are most effective

as thermal mass include: concrete, tile, brick and other materials with high Unit Interior Mass Capacities (UIMC) as listed in Table 3-12 and Table 3-13.

Thermal Mass is NOT required for Package D, only for compliance with Package C. The table above lists the minimum Interior Mass Capacity required for Package C. Note that Package C requirements are based on the building Ground Floor Area and the floor type. See the Glossary for the definition of Ground Floor Area for slab and raised-floor buildings.

The Interior Mass Capacity (IMC) of a material is calculated by multiplying its Area times its Unit Interior Mass Capacity (UIMC). Table 3-12 and Table 3-13 list the UIMCs for a number of thermal mass materials. The prescriptive thermal mass requirements may be met by adding the IMCs of all mass elements in the building.

This method allows for multiple mass types in both raised-floor and slab-on-grade construction. The Thermal Mass Worksheet (WS-1R) works through Equation 3-1 to calculate the IMC. On the WS-1R, describe each interior mass surface and enter its area and UIMC value (see Table 3-12 and Table 3-13). For each surface, multiply the surface area by the UIMC and add the results of all mass elements.

3.5.1 Slab Floor Interior Mass

The interior mass requirement for Package C slab-floor buildings is comparable to having 20% of the *ground floor slab area* exposed to the conditioned space. This assumes a standard weight (140lb/ft^3) concrete slab at least 3.5 inches thick. A Package C slab-floor building may meet its thermal mass requirement by either calculating the IMC of all of the mass elements in the building, or by exposing 20% of a 3.5-inch concrete slab.

Table G-13 (in the Appendix) contains a complete list of floor coverings that qualify as *exposed* mass. This list includes brick, ceramic tile, stamped concrete (acceptable in any location), vinyl tile, sheet vinyl and unfinished concrete (only when located in kitchens, dining areas, pantries, bathrooms, laundry rooms, service porches and entries).

3.5.2 Raised Floor Interior Mass

The interior mass requirement for Package C raised-floor buildings is based on having mass equivalent in performance to 5% of the ground floor area consisting of exposed two-inch thick concrete slab with a volumetric heat capacity of 28, a conductivity of 0.98, a surface conductance of 1.3 and no thermal resistance on the surface. The heat capacity and conductivity performance equivalent referred to is that of standard 140 lb/ft^3 concrete.

Table 3-12 – Interior Mass UIMC Values: Interior Mass[9] - Surfaces Exposed on One Side[10]

Material	*Surface Condition*	*Mass Thickness (inches)*	*Unit Interior Mass Capacity*
Concrete	Exposed[1]	2.00	3.6
Slab-on-Grade and		3.50	4.6
Raised Concrete Floors		6.00	5.1
	Covered[2]	2.00	1.6
		3.50	1.8
		6.00	1.9
Lightweight Concrete[8]	Exposed	0.75	1.0
		1.00	1.4
		1.50	2.0
		2.00	2.5
	Covered	0.75	0.9
		1.00	1.0
		1.50	1.2
		2.00	1.4
Solid Wood	Exposed	1.50	1.2
		3.00	1.6
Tile[3,]	Exposed	0.50	0.8
		1.00	1.7
		1.50	2.4
		2.00	3.0
Masonry[4,8]	Exposed	1.00	2.0
		2.00	2.7
		4.00	4.2
Adobe[8]	Exposed	4.00	3.8
		6.00	3.9
		8.00	3.9
Framed Wall	0.50" Gypsum	na	0.0
	0.63" Gypsum	na	0.1
	1.00" Gypsum	na	0.5
	0.88" Stucco	na	1.1
Masonry Infill[7]	0.50" Gypsum	3.50	1.3

Table 3-13 – Interior Mass UIMC Values: Interior Mass[9] - Surfaces Exposed on Two Sides[5, 10]

Material	Surface Condition	Mass Thickness (inches)	Unit Interior Mass Capacity
Partial Grout	Exposed[1]	4.00	6.9
Masonry[4]		6.00	7.4
		8.00	7.4
Solid Grout	Exposed	4.00	8.3
Masonry[4,6]		6.00	9.2
		8.00	9.6
Adobe	Exposed	4.00	7.6
		12.00	7.8
		16.00	7.6
Solid Wood/	Exposed	3.00	3.3
Logs		4.00	3.3
		6.00	3.3
		8.00	3.3
Framed Wall	0.50" Gypsum	na	0.0
	0.63" Gypsum	na	0.2
	1.00" Gypsum	na	0.9
	0.88" Stucco	na	2.1
Masonry Infill[7]	0.50" Gypsum	3.50	2.6

Notes For Table 3-12 and Table 3-13

1. "Exposed" means that the mass is directly exposed to room air or covered with a conductive material such as ceramic tile.

2. "Covered" includes carpet, cabinets, closets or walls.

3. The indicated thickness includes both the tile and the mortar bed, when applicable.

4. Masonry includes brick, stone, concrete masonry units, hollow clay tile and other masonry materials.

5. The unit interior mass capacity for surfaces exposed on two sides is based on the area of one side only.

6. "Solid Grout Masonry" means that all the cells of the masonry units are filled with grout.

7. The indicated thickness for masonry infill is for the masonry material itself.

8. Mass located inside exterior walls or ceilings may be considered interior mass (exposed one side) when it is insulated on the exterior with at least R-11 insulation, or a total resistance of R-9 including framing effects.

9. When mass types are layered, e.g. tile over slab-on-grade or lightweight concrete floor, only the mass type with the greatest interior mass capacity may be accounted for, based on the total thickness of both layers.

10. Values based on properties of materials listed in 1993 *ASHRAE Handbook of Fundamentals.*

The builder should install mass materials and exposed surfaces in accordance with the thermal mass requirements shown on the CF-1R. When the CF-1R shows Package C was used, it is important that the material type and area in the building be consistent with those shown on the form. Field changes could result in the building not complying with the prescriptive approach. If changes occur, it will be necessary to recalculate thermal mass compliance for the entire building with a different compliance approach.

With the Package C prescriptive approach, there are three possibilities:

- Thermal mass is consistent with the specifications on the CF-1R for mass materials, including floors covered or exposed, or
- The “as built” thermal mass conditions are checked for compliance with the prescriptive package selected; or
- The calculations are resubmitted to demonstrate compliance with a different compliance approach.

3.6 Space Conditioning Systems

§151(f) 6, 7, 9, and 10

6. *Heating System Type. Heating system types shall be installed as required in Tables No. 1-Z1 through 1-Z16. A gas heating system is a natural or liquefied petroleum gas heating system.*
7. *Space Heating and Space Cooling. When refrigerant charge and airflow measurement or thermostatic expansion valves are shown as required by Tables 1-Z1 through 1-Z16, ducted split system central air conditioners and ducted split system heat pumps shall either have refrigerant charge and airflow measurement confirmed through field verification and diagnostic testing in accordance with procedures set forth in the ACM Manual or shall be equipped with thermostatic expansion valve (TXV) with an access door or removable panel to verify installation of the TXV. All TXVs shall be confirmed through field verification and diagnostic testing as specified in the ACM Manual. All space heating and space cooling systems must comply with minimum appliance efficiency standards as specified in §110-§112.*
9. *Setback Thermostats. All heating systems shall have an automatic thermostat with a clock mechanism or other setback mechanism approved by the Executive Director which the building occupant can manually program to automatically set back the thermostat set points for at least 2 periods within 24 hours. The exception to §150(i) shall not apply to any heating system installed in conjunction with the packages specified in Tables No. 1-Z1 through 1-Z16.*
10. *Space conditioning ducts. All supply ducts shall either be in conditioned space or be insulated to a minimum installed level of R-4.2 and constructed to meet minimum mandatory requirements of §150(m). All duct systems shall be sealed, as confirmed through field verification and diagnostic testing, in accordance with procedures set forth in the ACM Manual.*

All heating systems must also comply with the mandatory measures explained in Chapter 2, including sizing according to design heating loads (see Section 2.5.2).

3.6.1 Gas Systems

All packages require that gas space-heating systems meet the minimum *Appliance Efficiency Regulations.* Package C additionally specifies a minimum of 78% Annual Fuel Utilization Efficiency (AFUE). Package D does not specify a minimum efficiency, allowing any gas space-heating device, including non-central furnaces, to be installed. See *AFUE* in the *Glossary* for a discussion of gas heating efficiency requirements.

3.6.2 Heat-Pump Systems

All heat pumps installed with the prescriptive packages must meet minimum appliance efficiency requirements. Package C limits split system air source heat pumps to a Heating Seasonal Performance Factor (HSPF) rating of 6.8 or higher. Single package air source heat pumps must have an HSPF rating of at least 6.6. Package D does not specify a minimum efficiency, allowing any heat pump, including non-central, to be installed.

3.6.3 Electric Resistance Heating

Electric resistance and electric radiant heating systems are allowed only in Package C. Package C may only be used for compliance if:

- The building is located in an area where natural gas is not currently available; and
- The local natural gas utility determines it is not practical to extend natural gas service to the site.

There are no minimum appliance efficiency standards for electric-resistance or electric-radiant heating systems.

3.6.4 Other Space-Heating Systems

Solar space-heating systems are not recognized within the prescriptive packages.

Wood heat is allowed with prescriptive compliance, provided all conditions as explained in Section 8.5 are met.

3.6.5 Space Cooling System Type

Air conditioners and the cooling cycle of heat pumps must meet or exceed the Seasonal Energy Efficiency Ratio (SEER) required by Package C. The value listed is the minimum established by the *Appliance Efficiency Regulations* for both split system and single package air conditioners or heat pumps. Split system air conditioners must have a minimum SEER of at least 10.0. The minimum SEER requirement for single package air conditioners is 9.7. Package D does not specify a minimum efficiency, allowing any space cooling device, including non-central units, to be installed.

3.6.6 Refrigerant Charge and Air Flow Measurement

The measurement and regulation of refrigerant charge and airflow can significantly improve the performance of air conditioning equipment. Refrigerants are the working fluids in air conditioning and heat pumps systems that absorb heat energy from one area (the evaporator) and transfer it to another (the condenser). This is accomplished through evaporation and condensation of the refrigerant for heat absorption and rejection respectively. Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge can lead to premature compressor failure and insufficient charge can cause compressors to overheat. In dry climates such as California, high airflow rates can increase the sensible capacity and total capacity and will increase the EER. Low airflow rates can lead to ice buildup on the cooling coil and compressor failure. The prescriptive standards require that a HERS rater verify that split systems have the correct refrigerant charge. See Section 4.3 and Appendix L for more information.

3.6.7 Thermostatic Expansion Valves

Thermostatic expansion valves (TXV) may be used as an alternative to diagnostic testing of the refrigerant charge and airflow across the coils. See Figure 3-3. TXVs are used in air conditioners or heat pumps to control the flow of refrigerant into the evaporator in response to the superheat of the refrigerant leaving it. The valve is placed upstream from the evaporator inlet and is connected to a temperature-sensing bulb and, when an external pressure bleed is used, a pressure tap located at the evaporator outlet. As the gaseous refrigerant leaves the evaporator the TXV senses its temperature and pressure (superheat) and adjusts the flow rate to maintain proper conditions. Eligible systems must provide a removable door for valve verification and testing by a certified HERS rater. An access door (or removable panel) is not required if the TXV is located outside the box. Package D requires either a TXV or testing of refrigerant charge and airflow in climate zones 2 and 8 through 15.

Figure 3-3 – Thermostatic Expansion Valve

3.6.8 Setback Thermostat

The prescriptive requirements (both Package C and D) require that all systems have a setback thermostat. The thermostat must have a clock or other mechanism, which allows the building occupant to schedule the heating and/or cooling setpoint temperature over a 24-hour period of time. In performance calculations, the budget building always has a setback thermostat, so there is an energy penalty if the proposed design does not have one. The setback thermostat must be designed so that the building occupant can program different temperature settings for at least two different time periods each day, for example, 68 °F during morning hours, 60 °F during the day, 68 °F during evening hours, and 60 °F at night.

An automatic setback thermostat is also a mandatory measure required for all space conditioning systems (see Section 2.5.3). However, there are exceptions to the mandatory measures for certain systems.

3.6.9 Ducts

For Package D, only the minimum R-4.2 duct insulation must be installed – a mandatory measure. However, Package C requires a minimum duct insulation of R-8. All duct systems shall be sealed, as confirmed through field verification and diagnostic testing, in accordance with procedures set forth in the ACM Manual. These procedures are described in Section 4.1 and Appendix J.

3.6.10 Documentation and Compliance

The builder should install:

- Equipment type as specified on the CF-1R
- Equipment efficiency as specified on the CF-1R
- Duct insulation as specified on the CF-1R
- Ducts in accordance with mandatory construction requirements from Section 2.5.7

The builder should:

- Obtain a Certificate of Field Verification and Diagnostic Testing (CF-4R) from a HERS rater for features that require field verification and diagnostic testing.
- Complete or obtain from the installer an Installation Certificate (CF-6R) for installed equipment.

Check the CF-1R for required measures and the CF-6R for installation information. The following are acceptable changes:

- Installing a heat pump instead of gas-heating equipment.

- Installing gas-heating equipment instead of a heat pump.

3.7 Water-Heating Systems

§ 151(b)1 and (f)8

Section 151(f)8:

All water heating systems must meet the water heating budgets calculated from Equation No. 1-N.

NOTE to Section 151(f)8.: Any gas type domestic water heater of 50 gallons or less, which is certified as meeting the Appliance Efficiency Standards, and which meets tank insulation requirements of 150(j) may be assumed to meet the water heating budget.

Section 151(b)1:

The annual water heating budget calculated from Equation No. 1-N may be met by either:

A. Calculating the energy consumption of the proposed water heating system using an approved calculation method without an external insulation wrap or

B. Installing any gas storage type non-recirculating water heating system that does not exceed 50 gallons of capacity, and that meets the minimum standards specified in the Appliance Efficiency Standards.

Note: Storage gas water heaters with an energy factor of less than 0.58 must be externally wrapped with insulation having an installed thermal resistance of R-12 or greater in accordance with §150(j).

All packages, except Package C, require that the installed water-heating system meet the water-heating energy budget. This means one 50-gallon or less, gas storage type water heater, non-recirculating. If the energy factor is below 0.58 (i.e., 0.53 - 0.579) an R-12 external insulation blanket is a mandatory requirement.

If the water-heating system is other than described in the previous paragraph, Table 3-14 through Table 3-17 list other water-heating systems that have been pre-calculated to meet the water-heating budget for residences. Those systems that comply are designated with a "Y"; systems that do not comply are designated with a "N".

Note: Interpolation is not allowed when using Table 3-14 through Table 3-17. If a water-heating efficiency falls between values on the table, use the lower value.

The remaining alternative is to show compliance with the water-heating budget as explained in Chapter 6.

Package C

Package C water-heating system complies if it meets the budget as explained above or by installing an electric-resistance water heater that is:

- Located within the building envelope; and
- Supplemented by either a solar water-heating system or a wood stove boiler, which provides at least 25% of the residence's water heating requirements. See Chapter 6 for documentation requirements and installation criteria for active and passive solar water-heating systems and wood stove boilers. The wood stove boiler credit is not allowed in Climate Zones 8, 10 or 15, or in other jurisdictions, which do not allow wood stoves.

Table 3-14 – Complying Water Heating Systems[1] – One Water Heater - No Auxiliary Credits

Water Heater Type[2]	CZ	Energy Factor	Distribution[3]			Recirculating Systems		
			STD	HWR POU	Pipe Insulation	No Control	Temp/ Timer	Demand/ Temp
SG50	All	0.53	Y[4]	Y	Y	N[4]	N	Y
		0.63	Y	Y	Y	N	Y	Y
		0.73	Y	Y	Y	Y	Y	Y
SG75	All	0.48	N	Y	N	N	N	N
		0.58	Y	Y	Y	N	N	Y
		0.68	Y	Y	Y	Y	Y	Y
SE	All	0.87	N	N	N	N	N	N
		0.93	N	N	N	N	N	N
IG[6]	All	0.80	Y	Y	Y			
IE	All	0.93	N	N				
HP	1,14	1.80	Y	Y	Y	N	N	Y
		2.20	Y	Y	Y	N	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	2-5,12	1.80	Y	Y	Y	N	N	Y
		2.20	Y	Y	Y	N	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	6-11 &	1.80	Y	Y	Y	N	N	Y
	13, 15	2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	16	1.80	N	N	N	N	N	N
		2.20	N	N	N	N	N	N
		2.60	Y	Y	Y	N	N	Y

Table 3-15 – Complying Water Heating Systems[1] – One Water Heater - Solar Credits[5]

Water Heater Type[2]	CZ	Energy Factor	Distribution[3]			Recirculating Systems		
			STD	HWR POU	Pipe Insulation	No Control	Temp/ Timer	Demand/ Temp
SG50	All	0.53	Y	Y	Y	Y	Y	Y
		0.63	Y	Y	Y	Y	Y	Y
		0.73	Y	Y	Y	Y	Y	Y
SG75	All	0.48	Y	Y	Y	Y	Y	Y
		0.58	Y	Y	Y	Y	Y	Y
		0.68	Y	Y	Y	Y	Y	Y
SE	All	0.87	N	Y	Y	N	N	Y
		0.93	Y	Y	Y	N	N	Y
IG[6]	All	0.80	Y	Y	Y			
IE	All	0.93	Y	Y				
HP	1,14	1.80	Y	Y	Y	Y	Y	Y
		2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	2-5,12	1.80	Y	Y	Y	Y	Y	Y
		2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	6-11&	1.80	Y	Y	Y	Y	Y	Y
	13, 15	2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	16	1.80	Y	Y	Y	N	N	Y
		2.20	Y	Y	Y	N	Y	Y
		2.60	Y	Y	Y	Y	Y	Y

Table 3-16 – Complying Water Heating Systems[1] – Two Water Heaters – No Auxiliary Credits

Water Heater Type[2]	CZ	Energy Factor	Distribution[3]			Recirculating Systems		
			STD	HWR POU	Pipe Insulation	No Control	Temp/ Timer	Demand/ Temp
SG50	All	0.53	N	N	N	N	N	N
		0.63	Y	Y	Y	N	N	Y
		0.73	Y	Y	Y	Y	N	Y
SG75	All	0.48	N	N	N	N	N	N
		0.58	N	Y	Y	N	Y	Y
		0.68	Y	Y	Y	N	Y	Y
SE	All	0.87	N	N	N	N	N	N
		0.93	N	N	N	N	N	N
IG[6]	All	0.80	N	N	N			
IE	All	0.93	N	N				
HP	1,14	1.80	N	N	N	N	N	N
		2.20	Y	Y	Y	N	N	Y
		2.60	Y	Y	Y	N	Y	Y
HP	2-5,12	1.80	N	Y	N	N	N	Y
		2.20	Y	Y	Y	N	N	Y
		2.60	Y	Y	Y	N	N	Y
HP	6-11 &	1.80	N	Y	Y	N	N	Y
	13, 15	2.20	Y	Y	Y	N	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	16	1.80	N	N	N	N	N	N
		2.20	N	N	N	N	N	N
		2.60	N	N	N	N	N	N

Table 3-17 – Complying Water Heating Systems[1] – Two Water Heaters – Solar Credits[5]

Water Heater Type[2]	CZ	Energy Factor	Distribution[3]			Recirculating Systems		
			STD	HWR POU	Pipe Insulation	No Control	Temp/ Timer	Demand/ Temp
SG50	All	0.53	Y	Y	Y	N	N	Y
		0.63	Y	Y	Y	Y	Y	Y
		0.73	Y	Y	Y	Y	Y	Y
SG75	All	0.48	N	N	N	N	N	N
		0.58	Y	Y	Y	Y	Y	Y
		0.68	Y	Y	Y	Y	Y	Y
SE	All	0.87	N	Y	Y	N	N	Y
		0.93	Y	Y	Y	N	N	Y
IG[6]	All	0.80	Y	Y	Y			
IE	All	0.93	Y	Y				
HP	1,14	1.80	Y	Y	Y	N	Y	Y
		2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	2-5,12	1.80	Y	Y	Y	Y	Y	Y
		2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	6-11 &	1.80	Y	Y	Y	N	Y	Y
	13, 15	2.20	Y	Y	Y	Y	Y	Y
		2.60	Y	Y	Y	Y	Y	Y
HP	16	1.80	N	N	N	N	N	N
		2.20	N	Y	N	N	N	N
		2.60	Y	Y	Y	N	N	Y

Table 3-18 – Reference Notes for Complying Water Heating Systems[1]

NOTES:

1. The water-heating systems listed here have been pre-calculated to determine compliance with the water-heating budgets (see Note 4). See Chapter 6 for the complete method, including definitions and installation criteria for all system components. NOTE: All storage tank water heaters with less than 0.58 energy factor are assumed to have R-12 external tank insulation. This insulation is a mandatory requirement for storage tank water heaters with an energy factor between 0.53 and 0.579.
2. Water heater types: SG50 = Storage gas, 50 gallons or less; SG75 = Storage gas, 51 to 75 gallons, less than 75,000 Btu/hr input; HP = Heat Pump, 50 gallons or less; IG = Instantaneous Gas, pilot loss may not exceed 600 Btu/hr; SE = Storage electric, 50 gallons or less. Note that compliance of heat pump water heaters varies by climate zone.
3. Distribution Systems: STD = Standard; HWR = Hot water recovery; POU = Point of use; Pipe Insul = Pipe insulation credit; Recirculation: NoCtrl = Recirculation system with no controls; Temp/Timer = Recirculation system with either temperature or timer controls; Demand/Temp = Recirculation system with either demand controls, or with a combination time/temperature control. Pipe insulation is required on the entire length of recirculating piping, except when equipped with demand control. For systems with parallel piping, use the water heating forms to determine if the system meets the water-heating budget. See Chapter 6 for installation criteria and definitions.
4. Water-heater systems listed with a "Y" meet the water-heating budget and must be installed with the applicable efficiency and distribution devices used to receive credits. Water heater systems listed with an "N" do not meet standard water-heating budget.
5. Solar credit requires 50% solar contribution. See Chapter 6.
6. For instantaneous gas water heaters (IG), the value listed in the Energy Factor column is the Recovery Efficiency (RE).

Install:

- Equipment type as specified on the CF-1R

- Equipment efficiency as specified on the CF-1R
- Distribution type specified on the CF-1R
- Pipe insulation:
    - R-4 on the first 5 feet hot and cold for nonrecirculating systems with pipe diameters of 2 inches or less, R-6 for pipe diameters greater than 2 inches.
    - Entire length of recirculating piping (mandatory except when equipped with demand control)
    - If “pipe insulation” is indicated, it was used for credit and the entire length of hot water piping must be insulated to R-4 (R-6 if pipe > 2”)

The builder should complete:

- Installation Certificate (CF-6R) for installed equipment.

The field inspector should check the CF-1R for required measures and the CF-6R for installation information.

3.8 Compliance Documentation

Documentation of the prescriptive compliance approach is simple. In many cases, the only requirement is to complete a residential Certificate of Compliance (CF-1R) form, as well as submit a Mandatory Measures Checklist (MF-1R).

On the CF-1R form, the climate zone and package selected for compliance should be specified. The building features and devices that must be installed to meet the package requirements are also indicated.

A Form 3R is required to document equivalent assembly R-values if the proposed R-value is not the same or higher than the R-value listed in the package.

Form S, Solar Heat Gain Coefficient (SHGC) Worksheet, is required to document fenestration and exterior shading combinations. When a fenestration product has an SHGC equal or lower to that required by the package, Form S is not required. Only exterior devices and SHGCs from Table 3-10 may be used in SHGC combination calculations for Form S.